Astronomical Geography.

SARK.

QB
46
.S24

LIBRARY OF CONGRESS.
Chap. 2B46 Copyright No. .....
Shelf .S24
UNITED STATES OF AMERICA.

AUG 31 1887

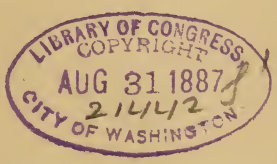
ASTRONOMICAL GEOGRAPHY.

BY

SAMUEL M. SARK,

A TEACHER IN THE COMMON SCHOOLS OF OHIO.

8
1464



CIRCLEVILLE, OHIO:
PUBLISHED BY THE AUTHOR.
1887.

Copyright, 1887,

By SAMUEL M. SARK.

RB46
.S24

Printed and Bound by the
UNION-HERALD PUBLISHING HOUSE,
CIRCLEVILLE, OHIO.

PREFACE.

A TEXT BOOK on PHYSICAL GEOGRAPHY has long been needed, specially adapted to advanced classes in our common schools.

It is the intention of the author to write such a text book on Physical Geography, but owing to the lack of means the first section, Astronomical Geography, now goes before the public asking my co-workers in the field of education to support me in carrying out the grand scheme of lifting our common schools to a higher plane of usefulness. In an experience of five years the author has found that our present system of Physical Geographies, written for high schools and colleges, are not adapted to the wants of our common schools. To meet these requirements and to encourage deeper investigation into the broad field of science, I place this little volume before the teachers of our country.

The author holds himself responsible for any errors that may have crept into the work ; but if any such there be, he

will feel under lasting obligations to those who will communicate the same to him. The work is the result of experience and patient toil, but if it supplies the demands for which it was written, the author will feel greatly rewarded for his work.

SAMUEL M. SARK.

Circleville O., August 22, 1887.

ELEMENTS OF ASTRONOMICAL GEOGRAPHY.

INTRODUCTION.

LESSON I.

1. DERIVATION.—The word, geography, is derived from the Greek ge, the earth, and graphein, to write. Its literal signification is, therefore, a description of the earth.

2. SPHERE OF GEOGRAPHY.—Strictly speaking, geography includes both an account of those changes which have been wrought by man, and those which have been produced by Nature. It treats not only of the earth, but of all things related to the earth. In its broadest sense it includes Astronomy, Geology, Mineralogy, Zoology, Meteorology, Phys-

ics, Botany, and various other sciences. Hence we see, that instead of geography being a distinct science, it is a collection of various sciences.

3. CLASSIFICATION.—There are two logical divisions of geography, political and physical.

POLITICAL GEOGRAPHY treats of the earth as the dwelling place of man ; of the society he has organized to promote his own welfare ; of the government he has originated to suppress his crimes ; of the religion he has invented to reverence a Supreme Being ; of his manner of living etc.

PHYSICAL GEOGRAPHY describes the extent and explains the cause of the various natural phenomena of the earth.

4. PHYSICAL GEOGRAPHY is subdivided into astronomical, physiographical, meteorological, zoological and botanical geography.

5. ASTRONOMICAL GEOGRAPHY is the science which considers the earth in its relation to the Universe, and in its relation to the Solar System.

6. PHYSIOGRAPHICAL GEOGRAPHY treats of the land and water belonging to the earth.

7. METEOROLOGICAL GEOGRAPHY is the science of the atmosphere and its phenomena.

8. ZOOLOGICAL GEOGRAPHY treats of animals and their distribution over the earth.

9. BOTANICAL GEOGRAPHY treats of the plants and their distribution.

10. MATHEMATICAL DEFINITIONS—(a) A point has position but no dimensions.

(b) A line is a magnitude which has length, but no volume.

(c) A straight line is one that does not change its direction throughout.

(d) A curve line is one that changes its direction at every point.

(e) Parallel lines are those, which, lying in the same plane, would never meet; no matter how far they be produced.

(f) An angle is the parting of two lines which meet.

(g) The point where the lines meet is called the vertex.

(h) An angle is named from a letter placed at its vertex as in fig. 1, which reads, the angle E or the angle F E G.

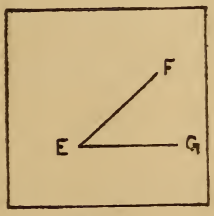


FIG. 1.

(i) The size of an angle depends entirely upon the difference in direction of its sides and not at all upon the length of those sides.

(j) A right angle is one formed by a straight line meet-

ing another straight line making the adjacent angles equal. The first line is then said to be perpendicular to the second.

(k) An obtuse angle is greater than a right angle.

(l) An acute angle is less than a right angle.

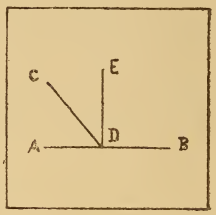


FIG. 2.

(m) In fig. 2, A D E and E D B are right angles. A D C is an acute angle. C D B is an obtuse angle.

(n) A convex surface is one that bulges out in a spherical form, like the outside of an egg shell.

(o) A concave surface curves in, like the inside of an egg shell.

(p) A plane has length and breadth without thickness.

(q) A circle is a plane bounded by a curve line, every point of which is equally distant from a point within called the center.

(r) The circumference of a circle is the line which bounds it.

(s) A straight line drawn from one side of the circle to the other, passing through the center is called the diameter.

(t) A straight line drawn from center to circumference is called the radius.

(u) The circumference of a circle is divided into 360 equal parts called degrees°.

(v) An angle is measured by the number of degrees in the arc that subtends it.

(w) AN ELLIPSE is a plane figure, bounded by a curve line, every point of which is at such distances from two points within, called its foci, that the sum of these distances is in each case the same.

(x) The center of an ellipse is the point midway between the foci.

(y) The Major Axis is the longest diameter.

(aa) The Minor Axis is the shortest diameter.

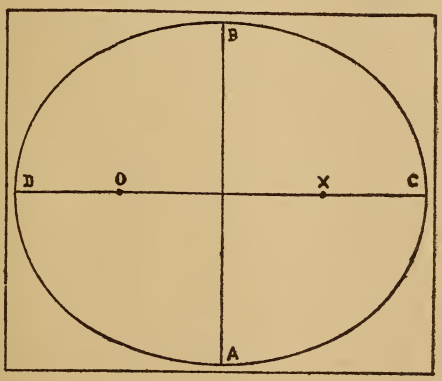


FIG. 3.

(bb) Fig. 3 represents an ellipse.

O and X are the foci.

D C is the major axis.

A B is the minor axis.

(cc) A solid has length, breadth, and thickness.

(dd) A SPHERE is a volume bounded by a curved surface, every point of which is equally distant from a point within called the center.

The diameter of a sphere is a straight line passing from one side, through the center, to the other side.

(ee) THE AXIS of a revolving sphere is the diameter around which it turns.

The ends of the axis are called the poles.

(ff) An Oblate Spheroid is a sphere flattened at the poles like an orange.

(gg) A Prolate Spheroid is a sphere elongated at the poles like a lemon.

SECTION I.

LESSON II.

1. THE UNIVERSE is the name applied to the entire material world.

There are truths before which man becomes humiliated and perplexed, although, he knows from the very nature of things, the absolute necessity of their existence. Among such are the eternal duration of time and the infinity of space. We live, therefore, in an expanse without limits, in whose bosom the universe is floating.

2. CONSTITUENTS OF THE UNIVERSE.—The first persons who studied the heavenly bodies fancied the Earth standing in the center of a hollow sphere ; that the stars were golden nails, which, seen on the concave surface, the great Architect of the universe had used in its construction.

Modern science teaches us that the universe is composed of Nebulae, Stars, Planets, Satellites, Comets and Meteors.

These bodies are divided into luminous and non-luminous bodies. Luminous bodies shine by their own light. Non luminous bodies shine by reflecting light of the luminous bodies.

3. NEBULAE--It has long been a subject of debate whether there existed a nebulous fluid in space. When the spectroscope was invented it forever ended the controversy. The nebulae (nebula, a cloud) are masses of glowing gas, probably, Hidrogen and Nitrogen.

The light of some of the nebulae, is subjected to great variations.

They are separated from us by such enormous distances that light, which travels at the enormous rate of 186,000 miles per second, requires many thousand years to reach us from some whose existence is revealed by the telescope. Many parts of the heavens having a nebulous appearance, contain no nebulae ; but the glowing mass consists of many stars, apparently, near each other, but doubtless, this appearance is due to the inconceivable distances they are apart from us ; and they are in reality as widely separated from each other, as the stars of our own Milky Way. Nearly all of the nebulae lie far beyond our stellar universe.

4. STARS.—Stars are huge balls of matter, which, floating in the depth of space, give us light because they are white hot. They are visible during the night, and are known by their twinkling ; but during the day their light is extinguished by the presence of the greater light of one glorious star, the Sun, whose rays light up and warm the earth. The stars are moving rapidly through space, al-

though, they are apparently at rest on account of the great distances they are from us.

The Sun appears to be the largest and brightest star in the firmament. This is because that orb is comparatively near us. The apparent feebleness of the stars is due to the great distances they are seperated from us; the nearest being more than 200,000 times more distant than the sun.

Some stars are much larger and brighter than the sun. As the land surveyor measures the distance across a river which he cannot cross, so, too, the astronomer spans the enormous distances from star to star.

Alpha Centauri is the nearest star, the Sun excepted. It is about 20,000,000,000,000 miles away. This is a truth which in our minds can form no conception. Yet this distance is small when compared with the distances of the stars of the 12th magnitude made visible by the telescope ; for it only takes light about three and a half years to reach us from Apha Centauri ; while if a star of the 12th magnitude would be at this moment destroyed, the inhabitants of the earth would continue to see it for 3,500 years. That is, it takes the light of these distant luminaries 3,500 years to reach us.

A cannon ball taking the earth as its starting point, traveling at the rate of 1,320 feet per second, would not arrive at Alpha Centauri in less than 2,500,000 years ; while a railroad train running at the rate of 40 miles per hour, would

arrive at that star in about 55,000,000 years. These distances are entirely to great for our conception, yet they are but mere points in boundless space.

5. The Magnitude of a star depends upon its relative brightness. The brightest stars are known as stars of the first magnitude ; while the most feeble visible to the naked eye, are of the sixth magnitude. There are about 20 stars of the first magnitude ; 65, of the second ; 200, of the third; 450, of fourth ; 1,100, of the fifth ; 4,000, of the sixth. The number increases largely in ascending the scale. From the above we see that the whole number of stars visible to the naked eye, is about 6,000.

Since we see but one-half of the sky, the greatest number visible at a time, is about 3,000. With a powerful telescope about 20,000,000 stars between the first and sixteenth magnitude, inclusive, are visible.

Of this number more than 18,000,000 belong to our own stellar universe, the Milky Way.

6. Constellations.—The stars are arranged in groups called constellations and are usually named after a fabulous personage or some animal which the relative position of the stars suggested to the mythological mind.

7 Variations.—The light of some of the stars, as in the case of the nebulae, is subjected to variations which, so far as we now know, occur in regular periods of time.

The cause of these variations is unknown, but three

theories have been advanced which are worthy of attention.

First—It is believed that all parts of the star's photosphere, or surface, are not equally luminous ; that it revolves upon its axis ; and, hence it is brightest when the brightest side is turned toward us, and darkest when the dark side meets our view.

Second—It is believed that the star has one or more non-luminous planets revolving around it ; that these planets get between us and the star forming either a total or partial ecilpse.

Third—It has been found that when a planet comes near the Sun it becomes brighter. Hence it is supposed that the variable has a large planet revolving around it ; and that that part of the star's photosphere nearest the planet will be brightest.

8. Color.—The light of most of the stars is white, but some are red, orange, blue, green, etc.

9. Constituents of the Stars.—We know but little of the elements of the stars ; however, we do know that their photospheres contain some elements known to us. Among the most widely diffused are Hidrogen, Sodium and Iron. The constituent elemets of the stars bear a striking resemblance to each other. It seems probable that each of these great luminaries has the same past history. At present, we are not prepared to conjecture about the future.

10. The Milky Way.—We have already spoken of

star-clusters under the head of nebulae. The sun, all of the stars visible to the naked eye, and millions of telescopic stars form one great star-cluster, known as the Milky Way. A ray of light traveling at the rate of 186,000 miles per second, starting at one side of the Milky Way, passing through the center, would reach the opposite side in about 15,000 years! Then leaving the last star in our cluster it would continue at its usual velocity, for several millions of years, through empty space and at last arrive at other star-clusters, some of them exceeding our own Milky Way in vastness of extent and numbers. Thus we see that the visible star-clusters, numbering about 5,000, and isolated from each other by inconceivable distances, are only so many milky ways floating in the bosom of infinite space.

LESSON III.

1. THE SOLAR SYSTEM.—The Solar System is situated in the center of that portion of the universe known as the Milky Way.

2. CONSTITUENTS. The Solar System is composed of the sun, planets, satellites, comets, meteors and an apparent ring of nebulous matter called the Zodiacal Light.

3. THE SUN is the center of the Solar System. It holds all the other members of the system in their respective places by its attraction.

It supplies the planets with light and heat, and supports all animal and vegetable life on our globe.

If we examine the Sun with a *telescope, we notice dark spots on its photosphere. By observing these spots, it is known that it turns on its axis in about 27 days; also that its axis is inclined to the plane of the ecliptic [See Chap. IV.] Since we know that the Sun rotates on its axis, and its disk is always a perfect circle, we conclude, therefore, that the Sun is a perfect sphere. The Sun is 852,584 miles in diameter, and it is nearly 1,300,000 times larger than the earth. Its weight, however, is only about 300,000 times as great.

The Sun is surrounded by a highly absorptive atmosphere which extends about 80,000 miles above its surface. In this atmosphere float incandescent clouds composed of vaporized metals and other constituent elements of a surface beneath. It is from these clouds whence the light so necessary to our existence is derived.

The Sun is a variable star with a period of 11 years.

We do not know what keeps up the Sun's great supply of light and heat, but we can theorize. A philosopher says, "One theory is good until a better one is given."

The constant supply of light and heat is supposed to be produced by the contraction of its cooling mass.

Another theory is, that meteors are constantly falling into

*Do not look at the Sun with even the smallest telescope, without proper instruction and appliances, for it is very dangerous. Some astronomers have lost their eyes.

the sun from interplanetary space. They arrive at its surface with enormous velocity, and being suddenly stopped their motion will be converted into heat. This theory, however, is now generally discarded for the first. How long the Sun will continue to supply our system with light and heat is not known. Certainly it can not last forever if not replenished, and we have no evidence that such is the case. A body in giving out heat becomes cooler. Hence we conclude that the Sun at some time, cold and lonely, will go falling through infinite space. The ice will gradually creep from the poles to the equator on our own terrestrial abode, and before its mighty tide man will dissappear from the face of the earth. Such we imagine will be the "end of the world." Astronomers, however, have no evidence of any loss of heat for several hundred years. Should the sad spectacle above mentioned occur, it need not trouble us, for there is enough energy stored up in that radiant orb to supply us with light and heat for many thousand years. The Sun is not stationary but is moving through space towards the constellation of Hercules at the rate of 4 miles per second. Many astronomers think our Solar System is revolving around Alcyone, the brightest star of the Pleiades. Since the Sun carries with it all of its attendants, we are constantly entering new realms of space.

Before leaving the Sun let us again glance at its vast extent in order to get it well impressed on our minds.

If the Sun were a hollow shell and the Earth placed at its center, there would not only be enough room for the Moon to revolve at its actual distance (240,000 miles,) around the Earth, but each part of its orbit would still be nearly 200,000 miles below the surface of the Sun. A railroad train traveling at the ordinary rate, would perform its journey around the Sun in about 10 years. We feel humiliated before its vast extent; yet the Sun forms but a molecule of the luminous matter of the universe.

LESSON IV.

1. PLANETS.—A planet is a body that revolves around the Sun in an almost circular path.

2. THE ORBIT of a planet is the path in which it travels.

3. The planets are non-luminous bodies, and shine by reflecting the light of the Sun.

4. The planes in which the orbits of the planets lie do not coincide; but nearly so.

5. The orbit of the Earth is called the Ecliptic.

6. The plane in which the orbit of the Earth lies is called the Plane of the Ecliptic.

7. MERCURY.—Mercury is the nearest planet to the Sun whose existence is known. It may be seen in the West, just above the Sun, after that body has set, or after a certain

time has elapsed, it may be seen in the morning before the Sun rises. Mercury is a little tinged with red and is the only planet that twinkles. Since its orbit is between us and the Sun it presents phases similar to the Moon. Its surface is rugged with mountains higher than those of the Earth. It has also evidences of a higher and denser atmosphere than our own. It revolves, around the Sun in a very eliptical orbit. When it is nearest the Sun it receives twice as much heat as when farthest away. It receives more than six times as much light and heat as our earth. Its mean distance from the Sun is about 35,000,000 miles ; its diameter 2960 miles ; its day 24 hs., 5 min., 30 sec. ; its year 88 of our days; the inclination on its axis, greater than that of the earth ; its seasons 22 days ; its volume 1/6 of the earth ; and its specific gravity about 7 ; that is, the average weight of its constituent parts is about 7 times greater than the weight of an equal bulk of water. Owing to the great eccentricity of its orbit and the inclination of its axis, its climate is subjected to great extremes. "Every 44 days on an average there is a change in temperature nearly equal to the difierence between frozen quicksilver and melted lead."

8. Venus.—Venus is the second planet from the Sun. Owing to its comparative nearness, it appears the largest and brightest planet. It is surrounded by a transparent atmosphere in which float the clouds that rise from its stormy

sea, presenting the same spetacle to us, we see every day on the Earth.

It rotates on its axis in 23 hrs. 21 min. Its inclination to a perpendicular to the plane of its orbit is very great, (49° 58′) and it is, therefore, like Mercury subjected to great extremes of temperature.

It revolves around the Sun in 224⅔ of our days, which is the length of its year. Its mountains are higher than those of the Earth.

Its mean distance from the Sun is about 66,000,000 miles. Its diameter is 7,510 miles ; its specific gravity about five and one-fifth; its volume about four-fifths of the Earth. It receives twice as much light and heat as the Earth. Venus being between us and the Sun, it presents phases similar to Mercury. The phases of both planets, however, are not visible to the naked eye.

Venus may be seen in the evening in a certain part of the year. It is then known as the Evening Star. After an elapse of a few months it may be seen in the morning before the Sun rises. It is then known as the Morning Star.

The planets we have already considered, are called inferior planets ; those which lie outside of the Earth's orbit are called superior planets.

9. Mars—Passing the Earth to be dealt with hereafter, we come to Mars the fourth planet in order from the Sun. Its day is about the same length of ours ; its year about 687

of our days; its diameter 4920 miles; its inclination of its axis about the same as the Earth, and, hence, its seasons about the same.

Mars has land, water, snow, clouds and mists the same as the Earth. You remember the color of the setting Sun is red. This is due to the absorption of its light in our atmosphere. The color of Mars is of a fiery red. This is due to the absorption of a part of the Sun's light; that is, the atmosphere of Mars acts as a sieve and stops all of the Sun's light but the red which it reflects to us.

A large white spot surrounds the south pole of Mars, and is supposed to consist of ice and snow. The orbit of Mars is very eccentric and the south pole being inclined towards the Sun when it is in that part of its orbit nearest the Sun, we would naturally expect the white spot to decrease during the planet's summer in its southern hemisphere. Now this is exactly what happens. Hence, the supposition that the white spot is a snow zone is very plausible. The mean distance of Mars from the Sun is about 139,000,000 miles.

LESSON V.

1. JUPITER.—Omitting the Asteroids of which we shall soon have something to say, we arrive at Jupiter, the largest planet of our system, and the fifth in order from the Sun.

It is 1,400 times larger than the Earth ; its mean distance from the Sun is about 476,000,000 miles ; the light and heat it receives from the Sun, but one-twenty-fifth as intense as that received by the Earth ; its day about 10 hrs., making it rotate so rapidly that a point on its equator travels about 27 times faster than one on the Earth's equator. Owing to its very rapid rotation the flattening of its poles is very great, its equatorial diameter being one-sixteenth longer than its polar. The axis of Jupiter is only inclined 3° 4′ to a perpendicular to the plane of its orbit. Hence there is no perceptible change of seasons.

Its year is equal to about 12 of our years. Jupiter is nearly as brilliant as Venus, and is always in the Zodiac [Lesson XIII] which makes it easily recognized. Its specific gravity is about 1⅜, which makes it weigh 300 times as much as the Earth.

2. SATURN.—Saturn, the sixth planet in order from the Sun, is 734 times as large as the Earth. It rotates very rapidly on its axis ; its days being only 10½ hours long. Its year is equal to about 29½ of our years ; the inclination of its equator to the plane of its orbit 26¾°, and, hence its seasons are subjected to changes similar to those of the Earth ; its mean distance from the Sun is about 872,000,000 miles ; and its specific gravity only two-thirds.

Around Saturn, 20,000 miles above its equator, rises a huge flat ring. This ring is followed by a second and the

second by a third. This system of multiple rings is only about 100 miles thick but it is 160,000 miles in diameter and 38,000 miles broad.

The rings are not stationary, but revolve around Saturn with greater rapidity than the planet itself. Close observation has revealed that the rings are undergoing changes.

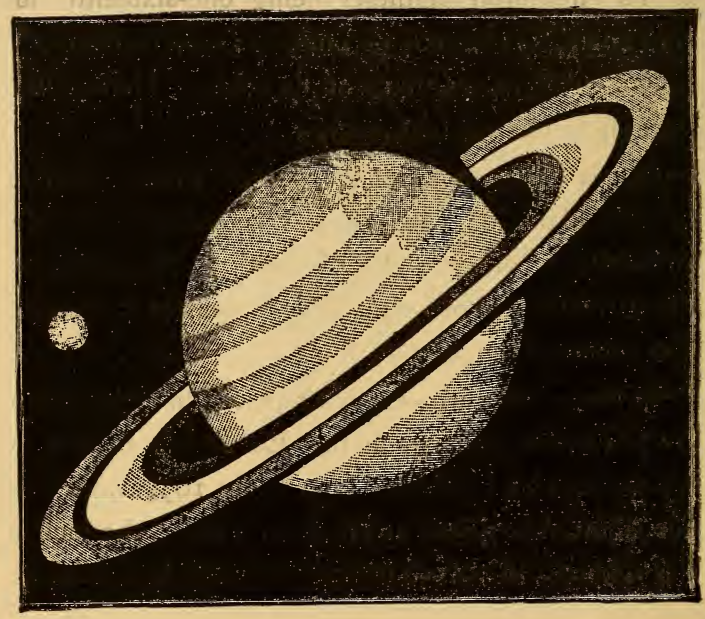


FIG. 4.—Saturn and its rings compared as to size with the Earth.

The general supposition is that these rings are composed of many little satellites, each moving independently in its own course around the planet, and being closely packed together, they present the appearance of bright rings.

3. URANUS.—The six planets already named were known

to the ancients. The rest have been discovered in modern times.

In 1781, Sir William Herschel discovered the seventh planet in order from the Sun, and it is called Uranus. It is just visible to the naked eye. Its year is equal to 84 of our years, but there being no spots on its surface, we are not able to tell its period of rotation. It is 72 times as large as the Earth; its specific gravity is nearly 1. The mean distance from the Sun is 1,754,000,000 miles.

4. NEPTUNE.—The discovery of Neptune is one of the grandest triumphs of modern science.

Every molecule of matter in the universe attracts every other molecule, and after taking all the known causes into account, there was still something that effected the motions of Uranus. This led to the belief that there was another planet beyond the orbit of this planet. Le Verrier, a French astronomer, proved by a mathematical calculation that there must be another planet beyond the orbit of Uranus, and wrote to Berlin observers, telling them where he imagined the planet to be. Following Le Verrier's directions, the planet was discovered the same evening. (September 1846.)

Like Uranus, Neptune's period of rotation is unknown; its year is equal to 165 of our years; its specific gravity nine-tenths, and its mean distance from the Sun is 2,746,000,000 miles.

The intensity of its light and heat is only about one-nine hundredth as great as that of the earth.

5. The Planets in General.—The eight planets already named in the order of their sizes are : Jupiter, Saturn, Neptune, Uranus, Earth, Venus, Mars and Mercury. On account of their large size they are called Major Planets, the remainder are very small and are called Minor Planets. or Planetoids.

LESSON VI.

---

1. The Asteroids—The Asteroids,or minor planets revolve around the Sun between the orbits of Mars and Jupiter. Their average distance from the Sun is about 260,000,000 miles. The discovery of the asteroids is due to what is known as Bode's Law. Let us write down

0 3 6 12 24 48 96

and add 4 to each number ; we now have

4 7 10 16 28 52 100.

This series of numbers represents the distances of the ancient planets from the Sun. 4, represents Mercury ; 7, Venus ; 10, Earth ; 16, Mars ; 28,———— ; 52, Jupiter ; an 100, Saturn. 28 has apparently no planet to represent. Kepler boldly placed an undiscovered planet in the gap, but up to the discovery of Uranus the suspected planet had

not revealed itself. When, however, this planet was discovered, and it was found that the next number in Bode's series, 196, would represent its distance, a society of astronomers was formed, and search made for it.

On Jan. 1, 1800, Ceres was discovered which filled up the gap. Since that time many others have been added, and there are now (1887) 264, known to exist.

Only two of these planets, Ceres and Vesta, are sometimes visible to the naked eye; the largest being only 228 miles in diameter. The force of gravity must be very small. The inhabitants of these planets can all be clowns, for a man could easily jump 50 feet high on one of their surfaces and sustain but a slight shock on descending. There are evidences of an atmosphere on some of the planets.

Some of them also seeem to rotate on their axis.

It is generally believed that the minor planets are the fragments of a large planet shattered by coming in contact with some other heavenly body.

According to Le Verrier's computation there must be about 150,000! of these little bodies between the orbits of Mars and Jupiter.

2. SATELLITES.—Those planets which revolve around the Sun as a center, are called primary planets. Those which revolve around the primary planets, are called secondary planets or satellites. Since the secondary planets accompany the primaries around the Sun, and the Sun moves

through space, we see that the motions of the satellites is a very complex subject.

The Earth has one satellite called the Moon ; Mars two ; Jupiter four ; Saturn eight ; Uranus six ; Neptune one.

The satellites, with the exception of those of Uranus and Neptune, revolve around their primaries the same direction that these planets rotate, namely, from West to East.

The primaries all revolve around the Sun from West to East, or in the opposite direction to the hands of a clock. There being such a wonderful uniformity in the direction of rotation and revolution of the planets and their satellites so nearly in the same plane, it has led to a very popular and plausible hypothesis now used almost exclusively by scientists to explain how the Solar System originated.

3. Laplace's Nebular Hypothesis—This hypothesis was advanced by the celebrated French astronomer, Laplace. It assumes that all the matter now belonging to the Solar System was once scattered throughout the space now occupied by that system, in a highly heated condition, forming a vast Nebula which probably extended far beyond the orbit of Neptune.

By and by the mass began to cool and the force of gravity overcame the repellent force of heat, and the matter constituting it began to contract.

It is a very well known law in Philosophy that whenever

matter seeks *a center a rotary motion is acquired.

As the cooling mass contracted the rotary motion necessarily increased ; the centrifugal force at the surface overcame the force of gravity and ring like masses of nebulous matter were thrown off and collecting in spherical masses, they formed the planets which for a similar reason acquired a rotary motion and detached their satellites.

If this supposition is true, when the rings of Saturn were thrown off several of them did not break up into globes but still remain as rings revolving around the planet. It is very probable that if these rings have not already broken up into many little satellites, that they will sometime do so. Mitchell very appropriately remarks that "Saturn's rings were left to show us how the world was made." The ring which formed the Asteroids probably broke up into many fragments, none large enough to attract the rest, and form a single globe ; while the central mass of the nebula contracted and formed the Sun.

The theory is perfectly consistent with strict mechanical principles, yet we must remember that it is only a hypothesis, and it must be dealt with as such

We should also remember that the strongest evidence to confirm the truth of any theory is its ability to explain phenomena, and this is strikingly true of this hypothesis. All observations tend to prove its correctness. The theory be

*Examples of this law are seen in every day life, as water poured into a funnel, a whirlwind or a water-spout.

ing sustained by so many facts, we shall entertain it in the absence of positive counter evidence.

LESSON VII.

1. THE MOON.—The Moon is 2,153 miles in diameter. It would take 49 Moons to make a planet as large as the Earth.

Its orbit is very eliptical, the center of the earth being at one of the foci; its average distance from the Earth is nearly 240,000 miles. When in that part of its orbit nearest the earth, it is said to be in perigee, and when in that part of its orbit farthest away it is said to be in opogee. To an inhabitant of the Moon the Earth must look at least twelve times as large as the Moon looks to us; while the Earth's phases would be similar to those we see in the Moon. The eclipse of the Earth would be on a much smaller scale than the eclipse of the Moon and the eclipse of the Sun would be a phenomenon many times greater than we see on the earth. It makes one revolution from West to East around the Earth in 27⅓ days. This period is called the sidereal month. The Earth in the mean time traveling around the Sun changes its position with respect to the Sun, so that it takes the Moon about 29½ days to make one revolution with respect to the Sun. This is called the synodic month, and is the time from one New Moon till the next.

The Moon rotates on its axis from West to East in exactly the same time in which it accomplishes its sidereal revolution, hence we never see but one side of our satellite. Viewed with a most powerful telescope the Moon appears as it would to the naked eye 80 miles away.

It has no atmosphere, hence to an observer on the Moon it would present a very peculiar aspect. There is no sound; no wind; no cloud to dot the sky. There being no atmosphere to reflect the Sun's rays, there is no twilight in the morning or evening, but the light of day comes like a flash, and goes as quick as it came.

There a person can not see through his own shadow, but every place where the direct rays of the Sun do not reach is as a deep, dark dungeon, through which we can not see. No water is there to quench one's thirst; but everything is a rainless desert as quiet and voiceless as the grave.

2. The Moon's Phases—The Moon is a non-luminous body and like the planets, it shines by reflecting the light of the Sun.

When the Moon is between the Earth and the Sun, the side turned away from the Earth is lit up, because it is turned toward the Sun; while that part turned toward us is invisible, because it is turned away from the Sun. We then have New Moon.

As the Moon progresses in the course of its revolution, it gradually presents its illuminated portion to us, and we get

a glimpse, as it were, of the bright side for a little while after sunset. We then have the Crescent Moon.

When the two lines passing from the Moon to the Earth and Sun, respectively, form a right angle, we see one half of the illuminated side. We then have the First Quarter.

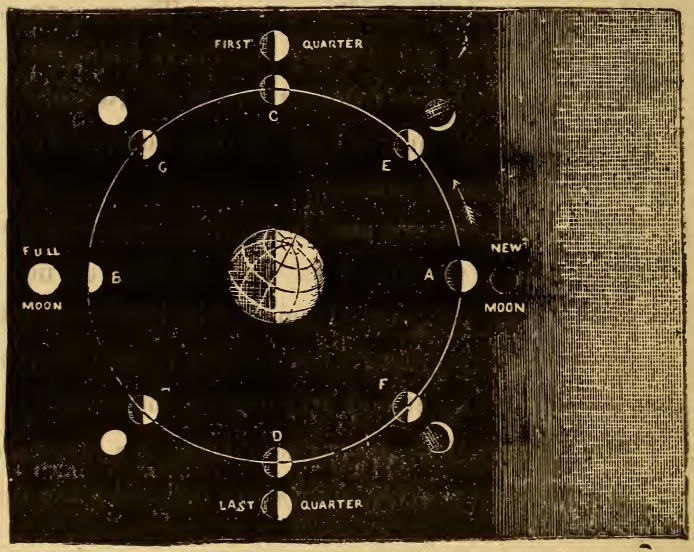


FIG. 5.—The Moon's Phases.

Next we see more than one-half of the Moon's disk. We then have Gibbous Moon.

Again we have the Earth between the Sun and Moon, and we see all of the illuminated portion. We then have Full Moon.

From Full Moon we have similar phases in reverse order

until New Moon is again reached, when the cycle recommences.

From New Moon to Full Moon our satellite is said to wax or increase, while from Full Moon to the next New Moon, it is said to wane or decrease.

3. Eclipses.—If the orbit of the Moon coincided with the plane of the ecliptic, every time we have a New Moon that body would pass directly between us and the Sun, and shut off the Sun's light. This, however, is not the case. The plane in which the Moon performs its journey around the Earth, is inclined five degrees to the plane of the ecliptic. Hence we see that one half of the Moon's journey is performed North of the plane of the ecliptic and the other half South of it.

The orbit of the Moon must, therefore, pass through the plane of the ecliptic at two points. These points are called Nodes. Now if the Moon happens at either of these nodes, when they are in line with the Earth and Sun, we have an eclipse. If the Sun and Moon are in conjunction, the New Moon passes between the Earth and Sun we have an eclipse of the Sun, the Earth passing through the shadow of the Moon ; but if the Sun and Moon are in opposition, the Full Moon enters and is hidden in the shadow of the Earth, and we have an eclipse of the Moon.

Since the Earth casts a larger shadow than the Moon, an eclipse of Moon lasts longer than one of the Sun.

If the Moon is near but not exactly at a node we have a partial eclipse.

Effects of Eclipses Upon the Ignorant.—We have neither time nor space to describe the effects of eclipses upon the ignorant masses. One illustration will suffice. Early in the year of 1504, Christopher Columbus, and crew, while on a voyage of discovery, were wrecked on the coast of Jamaica. They were on the point of starvation, and the natives refused to give them any provisions. Columbus knew that an eclipse of the Moon would occur on the night of March 1, of that year. Resorting to a stratagem, he told the natives that the Great Spirit was angry with them because they did not treat the Spaniards better, and would hide his face from them that night. The eclipse came and provisions came also, for when the Moon became dark, the Indians believing that Columbus had told the truth brought him bountiful supplies, beseeching him to induce the Great Spirit to receive them again into his favor.

Such superstition as this has stained the horizon of a thousand years with innocent blood, but a new era is now being ushered in, full of science and progress.

LESSON VIII.

Comets—We have other bodies revolving around the Sun besides the planets. They are masses of self luminous gas and are called Comets. They travel around the Sun in very

elongated orbits ; some of them completeing the cycle in a few years, while others require many thousand years. Instead of all revolving around the Sun from west to east like the planets, some of them revolve from east to west, while others strike the plane of the ecliptic at various angles.

Did you every see a comet ? It is a glorious spectacle projected on the sky. Its brightest portion is called the Coma or head. Some times the head contains a bright spot called the Nucleus.

The dimmer portion flowing from the head is called the Tail. All parts of the comet are of a very transparent nature. Stars may be seen through the tails where they are thousands of miles in diameter. Comets travel very slow when far away from the Sun, but their rate of travel greatly increases as they approach that body. Their brightness also increases as they approach that luminary. Gets of gas burst violently forth from the head towards the Sun, and being driven back, probably by the repulsive power of the Sun, a tail is formed varying from a million miles to more than one hundred million miles in length. The tail always points away from the Sun no matter whether the comet is traveling to or from the Sun.

2. Effects of Comets Upon the Ignorant.—Comets are usually regarded by foolish people as the sign of war, pestilence, and famine. Many people believe that the great comet of 1861 foretold the War of Secession.

It has long been feared that our Earth would sometime have a collision with some of these wanderers, and that they would destroy it; but the light of Modern science informs us that the mass of a comet is so extremely light and rare that we need not apprehend any danger.

In fact we have good evidence that our Earth passed through the tail of the brilliant comet of 1861, yet the only unusual phenomenon was a peculiar phosphorescent mist.

In 1776 a comet became entangled with the satellites of Jupiter, but the satellites pursued their journey around their primary as though nothing had happened, while the comet was thrown entirely out of its course and instead of being a long-period comet, it now accomplishes its revolution in about 20 years.

The following table will prove useful as a reference:

COMETS.	Time of Revolution.	Nearest approach to the Sun.	Greatest distance from the Sun.
	YEARS.	MILES.	MILES.
Encke's	3¼	32,000,000	387,000,000
De Vico's	5½	110,000,000	475,000,000
Brorsen's	5½	64,000,000	537,000.000
Biela's	6½	82,000,000	585,000,000
Faye's	7½	192,000.000	603,000,000
Halley's	76¾	56,000,000	3,200,000,000

3. METEORS—Go out on a clear night and the chances are you will see what you fancy to be stars shooting across the sky. These are small bodies called meteors which revolve around the Sun like planets, and are composed of metallic iron and various compounds of silica. The

greatest fall of meteors is about the 14th of November.

It has been calculated that these bodies revolve around the Sun in an eliptical orbit whose perhelion lies in the Earth's orbit and its aphelion just beyond the orbit of Uranus ; that its inclination to the plane of the ecliptic is 17°. And that the motion of these bodies is from east to west is proven beyond doubt. The Earth sailing along in its orbit encounters the meteors at their perihelion point about Nov. 14th. Hence the Nov. shower. They do not seem to be uniformly distributed throughout their orbit, but travel in several groups. Up to this time 56 such collections have been detected. These groups complete their revolution in about 33 years, and hence those great November showers, which make the sky put on a phosphorescent appearance, only occur at intervals of 33 years ; but as they extend a great distance along their orbit, they are several years in passing one point. We may, therefore, expect brilliant showers for two or three consecutive years. The last great shower was in 1866, while the same phenomenon will again occur in Nov. 1899 or 1900.

Traveling at the rate of 30 miles per second, they enter our atmosphere which acting as a break makes them so hot by its friction that they are usually vaporized before reaching the solid earth, and leave a train of luminous matter behind them. Many, however, reach the earth, often greatly damaging whatever happens in their way. Some of the

larger ones even explode on becoming intensely heated ; the fragments consisting of red hot stones being scattered over an area of several square miles

Meteors bear evidences of having been in such a highly heated condition as to be in a state of fusion. How these little bodies were "created" has never been satisfactorily explained.

4. The Zodiacal Light—The Zodiacal Light may be seen at certain times in the west just after sunset and in the east before sunrise. Its shape is that of a cone ; its base is turned toward the Sun ; and its axis lies in the plane of the ecliptic. Its true position in the Solar System is only a matter of conjecture. Some think it is due to a great multitude of meteors which surround the Sun and reflect its light ; others attribute it to an immense number of these little bodies which are constantly entering and being burnt up in our own atmosphere.

What the Zodiacal Light is, is, therefore, only an opinion based upon an imperfect knowledge.

SECTION II.

LESSON IX.

1. The Earth.—In discussing the planets we passed over the Earth. We shall now have a great deal to say about it. The Earth is the planet upon which we live and like other planets it revolves around the Sun ; its orbit lies between the orbits of Mars and Venus ; its mean distance from the Sun is about 91,500,000.

It was formerly supposed that the Earth was stationary and that it rested on something,probably, the back of an elephant. The elephant was supposed to stand on the back of a turtle. What the turtle stood on remains unanswered. ("Probably there are turtles the rest of the way down.")

Nothing is more false than such a theory. The earth rests on nothing. Being isolated from the other heavenly bodies, it moves through empty space around the Sun.

Before studying the motions of the earth we must needs first study the relations between matter and force, concisely expressed in several laws discovered by Sir Isaac Newton.

2. Law of Inertia.—A body at rest remains at rest, and a body in motion moves with uniform velocity in a

straight line, unless acted upon by some external force to change its condition.

Lay a book or other inanimate object upon the table and it will remain there until somebody or some external force moves it, because it has no power within itself to change its position.

Hurl a stone into the air. If acted upon by no external force, it will move onward forever, because it has no more power to stop than it had to start. Hence we see that matter has the property of keeping in motion when in motion, and remaining at rest when at rest. This property is called Inertia. The Law of Inertia is known in Physics as Newton's First Law of Motion.

3. Law of Universal Gravitation—When you threw the stone into the air it fell to the earth. What external force was the cause of its falling? We have told you in a previous lesson that every molecule of matter in the universe attracted every other molecule. The mutal attraction between particles of matter is called gravitation.

Now when you threw the stone skywards, its motion was lost on account of the resistance of the air and the attraction of the Earth.

The force of gravity of a sphere or spheroid acts upon a body of matter without it as if the attractive force was concentrated at its center, and this attraction varies inversely as the square of its distance from the center.

For example, take a man that weighs 180 lbs. at the Earth's surface. What would he weigh if transported 8,000 miles above its surface ?

Suppose the surface of the Earth to be 4,000 miles from its center. Then the man would be 4,000 plus 8,000 which is 12,000 miles from the Earth's center, or 12,000 divided by 4,000 equals 3 times as far as when he weighed 180lbs.

The square of 3 is 9. Hence he would weigh one-ninth of 180 or 20 lbs.

What would he weigh at the Earth's center ?

Nothing because he would be equally attracted on all sides.

If the force of gravity would cease what would become of the rocks, houses and the living beings that it holds to the earth ?

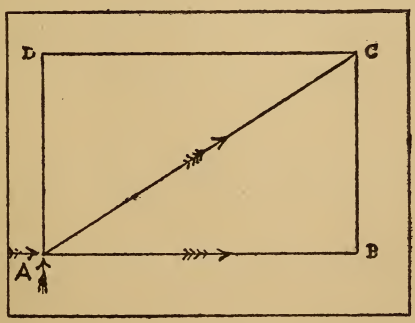


FIG. 6.

4. NEWTON'S SECOND LAW OF MOTION.—A given force has the same effect in producing motion, whether the

body on which it acts is in motion or at rest ; whether it is acted upon by that force alone, or by others at the same time.

In Fig. 6 suppose a ball at A to receive an impulse that sends it to B in one second ; then suppose it to receive another impulse at right angles to the line A B, that sends it to C in one second. Now instead of these forces acting separately, let us suppose that they both act at the same time, and that they be applied at A, at right angles to each other. The ball will then move over the diagonal A C of the parallelogram A B C D, and at the end of one second it will be found at C. Hence the Second Law of Motion.

LESSON X.

1. The Earth has two motions. It rotates on its axis and revolves around the Sun. The former is called its diurnal or daily motion ; the second its annual or yearly motion.

2. Cause of the Earth's Revolution—When the Earth was separated from the Nebulous Sun, it received a projectile force which has ever since been the cause of its motion through space. From its inertia alone, it must continue moving forever.

This motion, however, would be in a straight line if it were not for the gravitation of the other heavenly bodies.

This attraction causes, as we shall now explain, the curved paths of the planets.

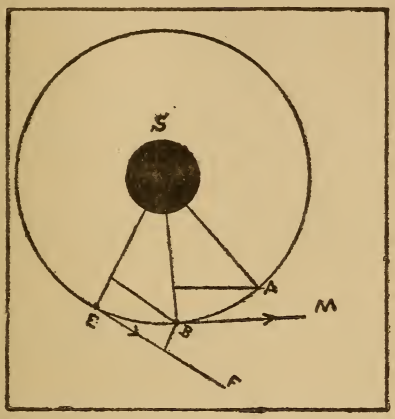


FIG. 7.

In fig. 7, S represents the Sun ; E the Earth. From its inertia, the Earth would move for an indefinite time in the direction E F, but the Sun's attraction constantly acting upon the Earth at right angles to its orbit causes our planet to change its direction at every point, by falling toward the Sun, and instead of traveling along the line E F or E S, its true path is between these lines along the curve line E B.

The inertia is sometimes called the centrifugal force, while the Sun's attraction is called the centripetal force. It is these two forces acting together that insures the safety of our world. If the centripetal force would cease at B, the Earth would pass off into space along the straight line B M,

but if the inertia would cease at B, the Earth would fall to the Sun along the line B S, and arriving at that luminary in 64 days after it started, it would disappear in its surface like a meteor in our own atmosphere.

3. PROOFS THAT THE EARTH REVOLVES.—There are many proofs of the Earth's revolution. Only a few of the more simple can be fully explained in a work like this.

1st. The change of seasons [Lesson XIX] is a proof of the Earth's revolution.

2d. All the stars in the firmament make one more apparent revolution in one year around the Earth than the Sun. This can only be satisfactorily explained on the supposition that the Earth revolves around the Sun.

3d. KEPLER'S FIRST LAW.—Each planet describes around the Sun an eliptical orbit, and the center of the Sun occupies one of the foci.

4th. KEPLER'S THIRD LAW.—The Earth is also included under Kepler's Third Law which is as follows: If the square of the time of revolution be divided by the cube of its mean distance from the Sun, the quotient will be the same for all the planets.

LESSON XI.

1. CAUSE OF THE EARTH'S ROTATION—When the Earth began its existence, after it had been separated from the

Nebulous Sun, its matter began to accumulate around a center on account of the contraction of its cooling mass. Hence it acquired a rotary motion. According to Lockyer the time of rotation has not changed, if any, more than one-sixty sixth of a second in 2,500 years.

2. PROOFS THAT THE EARTH ROTATES—

1st. From the laws of centrifugal force, it is impossible for the Sun and stars to revolve around the Earth. Hence the only natural conclusion is that the Earth turns on its axis.

2d. If the Earth rotates on its axis, its surface midway between the poles, known as the Equator, must necessarily travel fastest, while the motion decreases until it reaches the poles where it is zero. Hence from the greater centrifugal force, a body ought to loose some weight in being transported from the poles to the equator. This is exactly what happens. A body looses one two hundred and eighty-nineths of its weight upon being taken from either pole to the equator. From a law in philosophy, that the force increases as the square of the velocity, and since 289 is the square of 17, if the Earth turned 17 times faster, a body at the equator would wiegh nothing, while a stone hurled into the air would never fall to the earth.

3d. Drop a plumb-line from the top of a high tower to the earth and mark where it touches the ground ; then let a stone fall from the same point of the tower. It falls to the

east of the point marked. This shows that the Earth rotates from west to east.

4th. Foucault proved, by a pendulum experiment, that the earth rotates.

5th. The oblateness of the earth is the legitimate result of its diurnal motion.

3. SHAPE OF THE EARTH.—The true shape of the earth is that of an Oblate Spheroid. The equatorial diameter is twenty-six and five elevenths miles longer than the polar.

4. PROOFS THAT THE EARTH IS ROUND.—The earth being such a large sphere its surface everywhere appears flat. We shall, however, give ten proofs that it is spherical.

1st. CIRCUMNAVIGATION.—You all know that a fly can walk around an apple, so, too, a person can travel around the earth. Ships have often started at a certain place on the earth's surface, and by continuing in one direction for many weeks, have reached the starting point. This would be impossible, if the earth is not spherical.

2d. THE SENSIBLE HORIZON.—A person on top of a high mountain can see the earth slope away in all directions. The higher a person ascends, the more the circle formed by the apparent meeting of the earth and sky, is extended.

3. APPROACHING OBJECTS. If the earth was flat a person could see the lower half of an object as soon as the upper half. This, however, is not the case. When a ship

is coming into port, we first see the topmast, next the sails, and lastly, the hull meets our view.

Since this phenomenon occurs no matter from which direction the ship is approaching us, we conclude, therefore, that the earth is spherical.

4th. SHAPE OF THE HORIZON—The line where the earth and sky seem to meet is always the circumference of a circle. Now, if the Earth were flat, this would not be true, since to a person near the edge some other shape would meet our view.

5th. THE EARTH'S SHADOW—During an eclipse of the Moon, the Earth always casts a circular shadow upon our satellite. Since only spherical bodies cast circular shadows in all directions, the Earth must be spherical.

6th. WALLS OF A BUILDING.—The opposite walls of a building, if built perpendicular are farther apart at the top than at the bottom.

7th. RISING AND SETTING OF THE SUN.—If the earth were flat the Sun would rise and set everywhere at the same time. We know, however, that the Sun rises and sets east of us before it does west of us.

8th. POSITION OF THE NORTH STAR.—The North Star never sets. This would be impossible, if the earth was not spherical.

9th. UNEQUAL LENGTH OF DAY AND NIGHT.—If the Earth were flat, day and night would everywhere be of

equal length, throughout the year. Since this is not the case, we again infer that the Earth is spherical.

10th. MEASUREMENT—By actual measurement we not only find that the Earth is an oblate spheroid, but also the exact amount of its oblateness.

LESSON XII.

1. DIMENSIONS AND DENSITY OF THE EARTH—The polar diameter of the Earth is 7,899 and one hundred and ninety-nine five hundred and twenty-eighths miles, while the equatorial diameter is 7,925 and four hundred and thirty-eight five hundred and twenty-eighths miles. The circumferance is about 24,899miles, while the area of its surface is nearly 197,000,000 square miles. Of this only about 53,000,000 square miles is land area, while the remaining 144,000,000 square miles is water area.

The specific gravity of the Earth is about 5⅔, and its weight in round numbers is 6,000,000,000,000,000,000,000 tons!

2. CAUSE OF THE EARTH'S OBLATENESS—The oblateness of the earth is due to its rotation which caused it to bulge out at the equator, and put on its present shape, when it was in a fluid condition.

3. DOES THE MISSISSIPPI RIVER RUN UP HILL?—Since a river that flows towards the Equator has its mouth farther

from the center of the Earth than its source, it may, therefore, be truly said that it flows up hill, because up only means away from the center of the Earth, while down means towards the center of the Earth. For simplicity let us imagine a person at the Earth's center. He would look up no matter in what direction he would turn his head.

Again let us imagine a person at the equator and another at the poles to be looking down upon the person at the center. These persons would not look in the same direction, but on the contrary, they would look at right angles to each other.

Since up is away from the earth's center, and the mouth of the Mississippi river is over four miles farther from this center, than its source, it must, therefore, flow up hill.

4. WHY SOME RIVERS RUN UP HILL.—The same force which caused the earth to bulge out at the equator, also causes those rivers which flow up hill to do so. If the earth would cease to rotate, the waters of the Mississippi as well as those of the sea would all rush towards the poles, leaving the bottom of the sea dry at the equator, while the polar regions would be one vast sea, whose surface would everywhere be an equal distance from the earth's center.

5. POINTS

1st. HORIZON.—The place where the earth and sky seem to meet is called the Sensible Horizon.

2d. ZENITH.—The Zenith is a point in the heavens directly overhead.

3d. NADIR.—The Nadir is a point directly underfoot.

4th. NORTH.—North is the direction of the North Star.

5th. South.—South is the opposite direction.

6. EAST.—East is toward the place where the Sun rises.

7th. WEST—West is toward the place where the Sun sets.

8th. EQUINOCTIAL POINTS—Equinoctial Points are the points where the Sun crosses the Equator.

9th. North, East, South and West are called the Cardinal Points.

10th. The points midway between the cardinal points are called Semi-Cardinal Points.

LESSON XIII.

1. IMAGINARY LINES—For the purpose of locating places upon the Earth, we imagine it to be encircled by curve lines, the circumferences of circles.

(a) A Great Circle divides the earth into two equal parts.

The shortest distance between any two points on the earth's surface is along the arc of a great circle.

(b) A Small Circle is one that divides the earth into two unequal parts. The lines most frequently used in geography are the Equator, the Meridians, and the Parallels.

(c) The Equator is the circumference of that great circle which is equidistant from the poles, and which divides the earth into a northern and southern hemisphere.

(d) The Tropics are parallels which lie about 23½ degrees (exactly, 23°, 27′, 24″,) north and south of the equator. The one north of the equator is called the Tropic of Cancer, while the one south of it is called the Tropic of Capricorn.

The tropics are situated where they are because the Sun's vertical rays always stay within them.

(e) The Polar Circles are parallels which lie 23½ degrees from the poles. The one in the northern hemisphere is called the Arctic Circle, while the one in the southern hemisphere is called the Antarctic Circle.

(f) Meridians are the semi-circumferences of great circles, which are drawn from pole to pole. Of course there is an infinite number of meridians and parallels, since there is one of each passing through every point on the earth's surface.

2. Latitude.—Latitude is distance north or south of the equator expressed in ° ′ ″. It is measured on the meridians by the parallels.

Since the poles have the greatest distance possible from the equator of any object on the earth's surface, and that distance is ¼ of the circumference of a circle, the greatest latitude a place can have is ¼ of 360° or 90°. The equator has no latitude. Places north of the equator are in North Latitude, while those south of that line are in South Latitude.

3. LONGITUDE.—Longitude is the distance east or west of some established meridian expressed in ° ′ ″. It is measured on the parallels by the meridians, with the exception of those places situated upon the equator, whose longitude is measured upon the equator by the meridians.

The meridian from which time is reckoned is called the Prime Meridian. Nations usually reckon from the meridian of their own capitols. For example, the English reckon from the meridian which runs through the observatory at Greenwich, while we Americans reckon from Washington. A place east of the prime meridian is in East Longitude; a place west of this meridian is in West Longitude.

Since there are only 180° in a semi-circumference, the greatest longitude a place can have is 180°, for if a place be situated more than 180° in east longitude, it will fall in less than 180° west longitude.

The prime meridian and the poles have no longitude.

The place where the prime meridian crosses the Equator has neither latitude nor longitude.

4. VALUE OF DEGREES OF LATITUDE—Since latitude is measured on the meridians, the value of a degree of latitude is one three hundred and sixieth of the circumference of a great circle. On account of the Earth's flattening at the poles, the Earth's surface does not curve as fast as we approach those points as it does at the equator, and hence the meridians in high latitudes represent the circumferences of larger circles than they do at or near the Equator.

One degree of latitude is, therefore, longer at the poles than it is at the equator. The following table will prove useful as a reference.

PLACE.	LENGTH OF A DEGREE IN MILES.
Equator.	68.698
20 degrees	68.781
40 "	68.884
60 "	69.222
80 "	69,375
90 "	69.396

5. VALUE OF DEGREES OF LONGITUDE—The value of a degree of Longitude is subjected to great variations. On the Equator it is one three hundred and sixtieth of the Earth's circumference, while at any other place it is one three hundred and sixtieth of the parallel passing through that place. The parallels, as we have seen, decrease in length as we approach the poles, and, hence, the value of a degree of longitude must also decrease as the latitude increases, until the poles are reached, at which place, the value is zero.

Consult the following table.

PLACE.	LENTH OF A DEGREE IN MILES.
Equator	69.16
15 degrees	66.82
30 "	59.95
45 "	48.98
65 "	34.67
75 "	17.96
90 "	Zero

The above figures are given in common miles. A Geographical or Nautical mile is one three hundred and sixtieth of a degree on the equator or about 2025 yards. It is used for measuring distances at sea.

How long is the 45th parallel ?

How can we find the distance around the earth on any parallel, when the length of one degree is known ?

LESSON XIV.

1. LONGITUDE AND TIME—For our present purpose it is true enough to say that the time from one Noon till the next is 24hrs. Since the Sun appears to travel around the Earth in 24hrs., in 1hr., it will travel over one twenty-fourth of 360° or 15° of longitude ; while in one minute of time it will pass over one sixtieth of 15° or 15′ of longitude ; and in one second of time it will travel over one sixtieth of 15′ or 15″ of longitude.

Since the value of so many units of time is always equal to so many units of longitude, or vice versa a certain num-

ber of units of longitude is always equal to so many units of time, it is evident that if the value in either is known, the value in the other may be found.

2. The International Date Line or Sunday Line is the place where the days and nights are assumed to begin and end. It passes through the Pacific ocean. Immediately east of this line it is always one day earlier in the week than immediately west of it. For example, when it is Monday east of this line it is Tuesday west of it. If we travel around the earth from east to west we loose a day, but if we travel around the earth from west to east we gain a day. Hence we see the necessity of a correction at this line or we would soon have a remarkable confusion of dates. Navigators, however, are in the habit of making this correction at the 180th meridian from Greenwich.

3. Time Varies—When the Sun's vertical rays fall perpendicular upon any meridian, it is Noon (M, meridian) on that meridian ; east of this meridian the Sun's vertical rays have already passed, hence, it is afternoon (P M, postmeridian) at such places. The Sun's vertical rays, however, have not yet reached those places situated west of this meridian, and, hence, it is forenoon (A M, antemeridian) at such places.

4. Problem—Honolulu, Sandwich Islands, is in longitude 157°, 52′ west of Greenwich. Sidney, Australia, is in 151° 11′ east longitude. When it is five minutes after four o'clock

on Sunday morning at Honolulu, what is the hr. and day of the week at Sidney ?

5. SOLUTION—Going westward from Honolulu to the 180th meridian, we find that we have passed over the difference between 180° and 157°, 52′, which is 22° 8′. Dividing this by 15 we have 1hr., 28 min., 32sec. of time.

Since it is earlier at the 180th meridian by exactly this time, it must be 2 o'clock, 36min., 28sec., A M. Sunday at the above meridian. Now we have seen that it is one day later immediately west of this line than immediately east of it. The time immediately west of this line must, therefore, be 2 o'clock, 36 min., 28sec. A M Monday.

The difference between the 180th. meridian and Sidney is the difference between 180° and 151°, 11′ is 28°, 49′, which divided by 15 gives 1hr., 55min., 16sec. ; but since Sidney is west of the 180th meridian, it will be 1hr., 55min., 16 sec. earlier at the former than at the latter place, which time is the differance between 2hr., 36min., 28sec., and 1hr., 55min., 16sec., which is equal to 41min., and 12sec., A M, Monday. Ans.

Can you solve this problem by going east from Honolulu? If you can, do so.

LESSON XV.

1. PROJECTIONS.—The term projection means the different methods of drawing maps.

2. MAPS. A Map is a drawing representing the whole or part of the earth's surface.

3. MERCATORS PROJECTION.—Mercator's Projection represents the parallels and meridians as straight lines. The region around the poles are made to appear much larger in an eastern and western direction than they really are. It is therefore, not a true representation of the earth's surface, but as they show relative positions correctly, Mercator's projections are used by navigators and also in physical geographies.

4. ORTHOGRAPHIC PROJECTIONS.—An Orthographic Projection represents the earth's surface as it would appear to an observer viewing it at a great distance from the earth.

5. STEREOGRAPHIC PROJECTIONS.—A Stereographic projection represents the earth's surface as it would appear to an observer standing on the earth.

There are two stereographic projections used more frequently than others, the Equatorial and the Polar.

An Equatorial Projection is one in which the equator is taken as the center.

A Polar Projection is one in which one of the poles is taken as the center.

A Concave Projection is one used to represent a small portion of the earth's surface, as a State.

6. DIRECTIONS.—In all maps the top represents north ;

the right side east; the bottom south; and the left side west.

7. Hemispheres.—A hemisphere is half a sphere. The equator divides the earth into a Northern and Southern Hemisphere. The 20th meridian west and the 160th meridian east of Greenwich divide the earth into an Eastern and Western Hemisphere.

A great circle can also be passed through the Earth so dividing it into two parts that nearly all the water will be in one part and the land in the other. The first is called the Water Hemisphere and the second the Land Hemisphere.

The pole or center of the land hemisphere is near London, England, while the center of the water hemisphere is near the island of New Zealand.

LESSON XVI.

1. Day and Night.—Day and Night are caused by the rotation of the Earth on its axis. The side of the Earth turned towards the Sun is lit up, and it is day on that portion, while the opposite side is turned away from the Sun and lies hidden in its own shadow, and, hence, it is night on the non-illuminated portion.

As the Earth rotates it presents all of its parts to the Sun, hence, all parts of the Earth have day and night.

2. THE GREAT CIRCLE OF ILLUMINATION.—The line which separates the illuminated from the non-illuminated parts of the Earth is the circumference of a great circle and is called the Great Circle of Illumination.

3. THE SHAPE OF THE EARTH'S SHADOW.—The shape of the Earth's shadow is that of an immense cone with its base on the Earth and its apex about 850,000 miles distant.

4. LENGTH OF DAYS.—The rotation of the Earth also causes the stars to rise in the east and set in the west ; but on account of the Earth's yearly motion, the time that elapses from the time a star passes a meridian until it passes it again is not as great as the time that intervenes between one passage of the Sun over the same meridian and the next.

The time that elapses from one noon till the next noon is called the Solar Day. The length of the solar day varies ; its mean length is 24hrs.

The exact time that it takes the Earth to make one rotation or the time that intervenes between two successive passages of a star over a given meridian is called the Sidereal Day. It is 23hrs. 56min. 4sec. long.

5. DIFFERENCE BETWEEN THE SIDEREAL AND SOLAR DAY EXPLAINED.—In Fig. 8, S represents the Sun ; 1 represents the earth with the Sun over the meridian A. Now the earth travels along in its orbit from 1 to 2 in a sidereal day and changes its position with respect to the Sun, but on account of the enormous distance to a fixed star, no change

in position will be noticed with respect to one of these bodies, and hence, as a fixed star will appear over a meridian every time the earth makes one rotation. When the star is

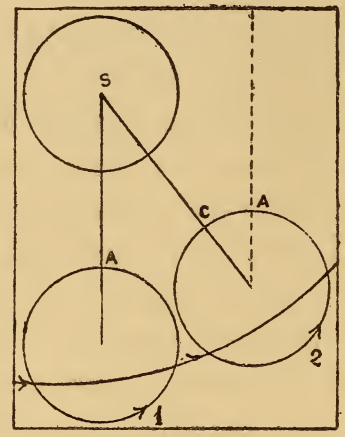


FIG. 8.

over A in 2, the Sun has not yet arrived over that point, but is directly over the meridian C. Therefore, the Sun will be behind the star by exactly the time it takes the earth to rotate from A to C.

LESSON XVII.

1. THE EARTH'S REVOLUTION.—Before discussing the variation of the solar day we must thoroughly understand the motion of the earth in its orbit. We have seen, Kepler's First Law, that the earth describes an eliptical orbit

around the Sun and that the center of the Sun occupies one of the foci of the elipse. Since this is not the center, the earth is not the same distance from the Sun in all parts of its orbit.

When the earth is in that part of its orbit nearest the Sun, it is said to be at Perihelion (Greek, peri, near and Helios, Sun). When it is in that part of its orbit which is farthest from the Sun it is said to be at its aphelion (Greek, apo, from and Helios, Sun). The earth's perihelion distance is about 90,000,000 miles while its aphelion is 93,000,000 miles. The Earth's orbit is 577,000,000 miles in extent. The earth does not travel the same rate at all times, but moves faster at perihelion than at aphelion. Its mean velocity is about 19 miles per second or 1,500 times faster than a fast railroad train.

The relative rate of the earth's revolution is concisely expressed in what is known as Kepler's Second Law, which is as follows :

The radius-vector of a planet sweeps over equal areas in equal times. By the radius-vector of a planet, we mean the line connecting that planet and the Sun.

In fig. 9 suppose the Sun at S, and the Earth at C ; the line C S is the radius-vector. Now suppose the Earth to travel from C to D in a certain period of time (say one month,) the radius-vector will have described the area C S D. Now, it is evident that when the Earth is nearest the Sun

and the radius-vector, therefore, shortest, that it must travel fastest to describe an equal area in an equal time. Thus F E is greater than D C, while A B is greater than F E, but the areas, S A B, S E F and S D C are all equal, each being described in one month.

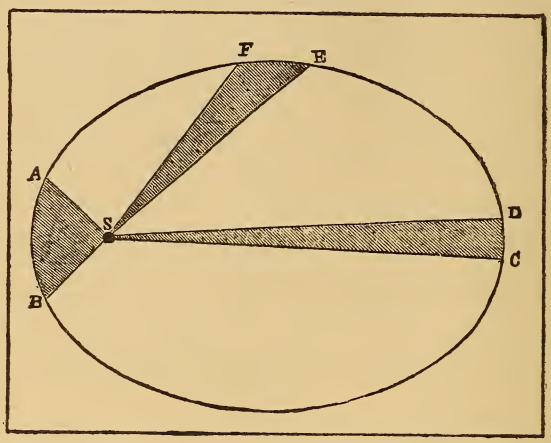


FIG. 9.

2. CAUSE OF THE VARIATION OF THE SOLAR DAYS.—It may be seen from Fig. 8., that the faster the earth travels in its orbit, the greater will be the the arc A C, and hence, the longer the solar day. Again the slower the earth travels, the shorter will be the arc A C and therefore, the shorter the solar day.

Therefore, the difference in the rate of travel of the earth in its orbit is the cause of the varation in length of the solar day.

3. "EQUATED TIME."—Equated Time is true clock

time. Twenty-four of its hours measure the mean length of solar day. This is also called Astronomical Time.

4. Sun Fast and Sun Slow.—Since a true clock measures the time of the mean Sun, it follows that at times it must be behind, and at other times ahead of true or Sun time. Now when the earth travels in its orbit faster than its mean rate, it will be seen by consulting Fig. 8, that it takes longer for the Sun to come to the meridian A, hence, the Sun is behind the clock and it is said to be slow.

When the earth travels in its orbit slower than its mean rate, the Sun arrives over the meridian A before the clock indicates noon, and hence, Sun time is in advance of the clock and the Sun is said to be fast.

From December 24th, to April 15th, the Sun is slow. From April 15th to June 15th, the Sun is fast. From June 15th, to September 1st, the Sun is slow.

From September 1st, to December 24th. the Sun is fast. At the above dates the equated and true time are the same.

5. Equation of Time.—The Equation of Time is the difference between the true solar day and the mean solar day. Thus on February 11th, the Sun is 14½ minutes behind the clock and the equation of time is written plus 14½, because it must be added to the time shown by a sun-dial to make it correspond to the time shown by a correct clock.

On May 14th, the Sun is 4 minutes fast, and the equation of time is written —4, because it must be subtracted from

Sun time to make it correspond to equated or clock time. On July 25th, the equation of time is plus 6; on November 1st minus 16¼.

LESSON XVIII.

1. The Zodiac.—By consulting Fig. 8, we see that if a fixed star and the Sun are together when the earth is at 1, they will not be together when the earth is at 2, but, on the other hand, the Sun will be to the east of the fixed star. As the earth progresses in its orbit, the Sun continues to move eastward among the stars until it makes one apparent revolution in the heavens. This zone or belt is called the Zodiac and is about 9° wide. The Zodiac is divided into 12 equal parts each part being called a Sign. Each sign, therefore, contains one twelfth of 360 or 30°.

The Earth moves through one twelfth of its orbit every month and hence, the Sun appears to move through a sign of the Zodiac every month. In the Zodiac may be found the Sun and major planets, also 12 constellations of stars named as follows:

Aries, the Ram.
Taurus, the Bull.
Gemini, the Twins.
Cancer, the Crab.

Leo, the Lion.
Virgo, the Virgin.
Libra, the Balance.
Scorpio, the Scorpion.
Sagittarius, the Archer.
Capricornus, the Goat.
Acquarius, the Water-bearer.
Pisces, the Fish.

They must not be confounded with the signs of the Zodiac of the same name and should be learned in the order named above. Since the stars make one more apparent revolution around the Earth than the Sun, every year, it follows that in a year of 365 days, the Earth makes 366 revolutions.

2. LENGTH OF DIFFERENT YEARS EXPLAINED.—The exact time that it takes the Earth to make one revolution is called the Sidereal Year. It is the time from one meeting of the Sun and a fixed star in the Zodiac until the next. Its length is 365 days, 6 hours, 9 minutes, and 9.6 seconds.

The attraction of the Sun on the equatorial protuberance of the Earth tending to make our planet settle down perpendicular to the plane of the ecliptic, causes the Earth's equator to meet the plane of the ecliptic before it makes one complete revolution; hence, the places where the equator crosses the plane of the ecliptic precede those places where it would cross this plane if the Earth were a

a perfect sphere ; hence, this motion of the earth is termed the Precession of the Equinoxes. This is called the Tropical Year, and is the time from one vernal equinox to the next. It measures 365 days, 5 hours, 48 minutes and 46.05 seconds. Again we may take the time from one perihelion to the next ; this is called the Anomalistic Year.

Now if the Earth's aphelion and perihelion points were stationary, there would be no difference between the anomalistic and the sidereal year, but these points are constantly moving forward making a complete revolution in 21,000 years ; hence, it takes longer for the Earth to travel from one perihelion to the next than it does to make one revolution. The anomalistic year measures 365 days, 6 hours 13 minutes, 49 seconds. At present we are at perihelion Janurary 1st. In about 4,600 years perihelion and the vernal equinox will correspond.

3. Effect of the Change of Aphelion and Perihelion.—Since we are in perihelion Janurary 1st., we are 3,000,000 miles nearer the Sun in winter, north of the equator, than in summer, while we are 3,000,000 miles nearer the Sun, south of the equator, in summer than in winter. This difference so intensifies the solar heat that Australia and other places in the southern hemisphere have a higher temperature than places of a corresponding latitude in the northern hemisphere. About 10,000 years ago the reverse must have

been true, the Earth being at perihelion at the time of our northern summer.

4. Effect of the Precession of the Equinoxes.—It is evident that the Earth's axis changes its direction on account of the precession.

The axis revolves around a point in the heavens in 25,870 years ; hence, the north star of to-day will not be the north star several thousand years from now.

LESSON XIX.

The Change of Seasons.—The Change of Seasons is caused by the revolution of the Earth together with the inclination of its axis and the constant parallelism of its axis.

First.—The inclination of the Earth's axis to a perpendicular to the plane of the ecliptic is nearly 23½° (exactly 23° 27′ 24″).

Second.—The Earth's axis always points in the same direction, namely, towards the north star ; hence, it matters not in what part of its orbit the Earth may be, its axis is always parallel to any former position.

Now the more nearly perpendicular the Sun's rays fall upon the earth, the more heat they produce, and since only one-half of the Earth is illuminated at a time, the point

where the Sun's vertical rays reach the Earth, is the pole of the illuminated portion.

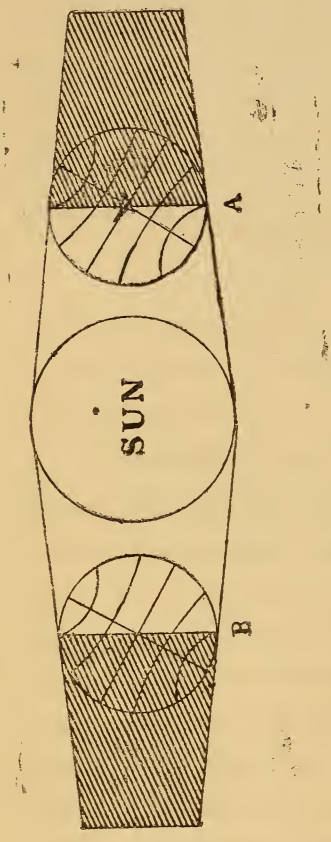


FIG. 10.

A and B in figure 10 represent the Earth at perihelion and aphelion. The south pole is now turned towards the Sun, and its rays fall perpendicular on the Tropic of Capricorn. We now have summer in the southern hemisphere, while in the northern hemisphere which receives the oblique rays, it is winter. When the Earth is at B or aphelion, the Sun's rays fall perpendicular upon the Tropic of Cancer. The northern hemisphere is now turned toward the Sun and we have summer north of the equator and winter south of it.

On the 22d. of March and again on the 22d. of September, the Sun's rays fall perpendicular upon the equator; at the former we have autumn in the southern hemisphere and spring in the northern; at the latter, we have spring in the southern and autumn in northern hemisphere. We now see that the three circumstances mention-

ed at the beginning of this paragraph, all play an important part in producing the change of seasons, for if either the inclination, parallelism of its axis, or the revolution of the Earth was wanting, different portions of the earth would not be constantly turning towards the Sun, and hence, there would be no cause to which the change of seasons could be attributed.

At the equator the days and nights are always of an equal length, (12 hours each.)

On the 22d, of March as we have already seen, the Sun's rays fall perpendicular upon the equator, and the oblique rays must, therefore, just reach the poles, hence, the days and nights are an equal length all over the Earth.

This is called the Vernal Equinox (Latin aequus, equal and nox, night). As the earth moves forward in its orbit, it gradually presents the northern hemisphere to the Sun, and its vertical rays reach higher latitudes every day. The rays must, therefore, reach places beyond the north pole, and in spite of the Earth's rotation, the Sun does not set at that place, and it is perpetual day, while the south pole is left in utter darkness. The Sun's vertical rays continue to recede from the equator until June 21st, when they cease. The earth is then near aphelion and the Sun's vertical rays fall upon the tropic of cancer. This is called the Summer Solstice (Latin, Sol, the Sun, and stare, to stand ; so named because the Sun upon reaching his northern and southern

limits seems to be stationary a short time in the heavens) and is the point where the Sun's vertical rays stop receding from the equator. Since the Sun's vertical rays now fall 23½° north of the equator, it follows that it rays also reach 23½° beyond the north pole, or to the artic circle. From June 21st the Sun's vertical rays again approach the equator until they once more fall upon that circle. This they do on the 22d of September and we then have the Autumnal Equinox.

All this time the north pole has been exposed to sunlight, hence, we see that at this place day lasts six months. Twilight now lasts about a month then all is dark and cold.

From the autumnal equinox the Sun's vertical rays again recede from the equator into the southern hemisphere until the 21st of December when they fall upon the tropic of capricorn. The Sun has now reached the Winter Solstice, and his rays pass over the south pole to the antarctic circle. The south pole now has perpetual day and the north pole one continued night. The Sun at this time is near perihelion and it at once reapproaches the equator, reaching that place on the 22nd of March, when it recommences a tropical year.

LESSON XX.

1. ZONES.—A zone is a division of the Earth. Of these

there are three principal kinds, namely, Mathematical, Physical and Zones of Time.

2. Mathematical Zones.—The Earth is divided into five mathematical or astronmical zones. They are bounded by the tropics and the polar circles.

3. The Frigid Zones.—The Frigid Zones lie between the polar circles and the poles. The one which surrounds the north pole is called the North Frigid, the one which surrounds the south pole the South Frigid.

4. The Temperate Zones.—The Temperate Zones lie between the tropics and the polar circles. The one north of the equator is called the North Temperate, the one south of the equator is called the South Temperate Zone.

5. The Torrid Zone.—The Torrid Zone is that belt of the Earth included between the tropics. The Sun's rays fall perpendicular upon one part or other of this zone every day of the year.

6. Width of the Zones.—The width of the Zones is as follows: Frigid 23½°; Temperate 43°; Torrid 46°.

The width of a zone depends upon the inclination of the axis of the planet it surrounds. If the Earth's axis were inclined 30°, instead of 23½°, the frigid zones would each be 30°; the torrid 60°; and each of the temperate 30° wide.

7. Physical Zones.—Physical Zones are bounded by lines drawn through places having the same mean annual temperature. These lines are called Isothermal Lines.

8. Zones of Time.—in order to avoid confusion of time in travelling from east to west or from west to east, railroad men have divided the Earth into 24 Zones ; each Zone is, therefore, one twenty-fourth of 360° or 15° wide. All places situated within any one Zone are made to have the same time, it being the time of a certain meridian of that Zone. This is called Railroad or Standard Time.

The following meridians are used : 0° is called Universal time ; West 15°, West African ; 30°, Central Atlantic ; 45°, East Brazilian ; 60°, La Plata ; 75° Eastern ; 90°, Central ; 105°, Mountain ; 120°, Pacific ; 135°, East Alaskan ; 150°, Central Alaskan ; 165°, West Alaskan ; 180°, Transitional ; East 165°, is called New Caledonian ; 150°, East Australian ; 135°, Corean ; 120°, East Asia ; 105°, Siam ; 90°, East Hindostan ; 75°, West Hindostan ; 60°, Ural ; 45°, Caucasus; 30°, Bosporus; 15°, Scandinavian.

9. Length of Day and Night.—When the Sun's vertical rays fall in either hemisphere, it is evident that more than one half of it will be illuminated, and the day will exceed the night in the proportion that the illuminated part of a parallel exceeds the non-illuminated part.

Since the Sun's rays at times pass over the poles to the polar circles, it follows that day in the frigid zones may exceed one complete rotation of the Earth. The following reference table exhibits the length of the longest day in the given latitudes.

Latitude.	Greatest Length of Day or Night.
Equator	12 hours
Tropics	13.5 "
30 Degrees	14 "
40 "	15 "
50 "	16.3 "
60 "	18.7 "
Polar Circles	24 "
67½ "	1 month
69½ "	2 "
73.3 "	3 "
78.3 "	4 "
84 "	5 "
Poles	6 "

10. Altitude.—By the altitude of a heavenly body we mean its distance in degrees above the horizon. Since the distance from the horizon to the Zenith is one fourth of a circle, the greatest altitude a body can have is 90 degrees.

Let us suppose you were standing on the north pole at the time of the vernal equinox; you would see the Sun at the horizon, and his altitude would then be zero; but suppose you travel to the south; then for every degeee you travel, the Sun's altitude increases one degree. Suppose you travel to Columbus, Ohio, which is in 40° north latitude; you will have traveled 90° minus 40° equals 50°, and hence the altitude of the Sun at Columbus on 22d of March is 50°.

What is the Sun's altitude on 21st of June? Since the Sun appears to move north 23½° from the March equinox till the 21st of June, the Sun's altitude must be 50° plus 23½° equals 73½°. Since the Sun appears to move south from the September equinox till the 21st of December, his altit-

tude at Columbus on the later date must be 50° minus 23½° equals 26½°.

What will be the Sun's altitude at Columbus May 1st?

Since the Sun travels north from March 22nd to June 21st, 23½ degrees in 91 days, he will travel $\frac{47}{2}$° divided by 91 equals $\frac{47}{182}$° in one day. The time from the vernal equinox to May 1st, is 40 days. Hence the Sun will have increased his altitude $\frac{47}{182}$° x 40 equals $10\frac{30}{91}$°.

Therefore, his altitude at Columbus is 50° plus $10\frac{30}{91}$° equals $60\frac{30}{91}$°.

11. WHAT NEXT? MY DEAR STUDENTS:—Our work is now finished. For some time we have enjoyed each others company and drank from the same cup of knowledge. Our minds have penetrated into the mighty depth of space and visited the wonders of the heavens. Trusting that by our voyage, we have all been strengthened in our gratefulness to the Great Master Mind of Creation; that we may go forth into the world and make STRONG, PURE, and NOBLE men and women; and that we may meet again in new fields, to explore the works of Nature, I bid you all Farewell.

THE END.

CORRECTIONS.—Opogee on page 30 should be apogee. [LESSON VIII,] page 23 should be [LESSON XVIII.]

CONTENTS.

INTRODUCTION.

PAGE.

Derivation 5
Sphere of Geography 5
Classification 6
Mathematical Definitions 7

LESSON II.

The Universe 11
Constitutents of the Universe 11
Nebulae 11
Stars 12
Magnitude 14
Constellations 14
Variations 14
Color 15
Constituents of the Stars 15
The Milky Way 15

LESSON III.

The Solar System 16

Constituents 16
The Sun 16

LESSON IV.

Planets 19
Mercury 19
Venus 20
Mars 21

LESSON V.

Jupiter 22
Saturn 23
Uranus 24
Neptune 25
The Planets in General 26

LESSON VI.

The Asteroids 26
Satellites 27
Laplace's Nebular Hypothesis . . . 27

LESSON VII.

The Moon 30
The Moon's Phases 31
Eclipses 33
Effects of Eclipses upon the Ignorant . . 34

LESSON VIII.

Comets 34
Effects of Comets upon the Ignorant . . 35
Meteors 36
The Zodiacal Light 38

LESSON IX.

The Earth 38
Law of Inertia 38
Law of Universal Gravitation . . . 40
Newton's Second Law of Motion . . . 41

LESSON X.

Motions of the Earth 42
Cause of the Earth's Revolution . . . 42
Proofs that the Earth Revolves . . 44

LESSON XI.

Cause of the Earth's Revolution . . . 44
Proofs that the Earth Rotates . . . 45
Shape of the Earth 46
Proofs that the Earth is round . . . 46

LESSON XII.

Dimensions and Density of the Earth . . 48
Cause of the Earth's Oblateness . . 48
Does the Mississippi River Run up Hill . . 48

Why some Rivers Run up Hill . . . 49
Points 49

LESSON XIII.

Imaginary Lines 50
Latitude 51
Longitude 52
Value of Degrees of Latitude . . . 53
Value of Degrees of Longitude . . 53

LESSON XIV.

Longitude and Time 54
International Date Line 55
Time Varies 55
Problem 55
Solution 56

LESSON XV.

Projections 56
Maps 57
Mercator's Projection 57
Orthographic Projections 57
Stereographic Projections . . . 57
Directions 57
Hemispheres 58

LESSON XVI.

Day and Night 58

The Great Circle of Illumination . . 59
The Shape of the Earth's Shadow . . . 59
Length of Days 59
Difference between the Sidereal and Solar Day Explained 59

LESSON XVII.

The Earth Revolution 60
Kepler's Second Law 27
Cause of the Varation of the Solar Days . . 62
"Equated Time" 62
Sun Fast and Sun Slow 63
Equation of Time 63

LESSON XVIII.

The Zodiac 64
Length of different Years Explained . . 65
Effects of the Change of Aphelion and Perihelion . 66
Effects of the Precession of the Equinoxes . . 67

LESSON XIX.

The Change of Seasons 67

LESSON XX

Zones 70
Mathematical Zones 71
The Frigid Zones 71

The Temperate Zones - - - 71
The Torrid Zone - - - - 71
Width of Zones - - - - 71
Physical Zones - - - - - 71
Zones of Time - - - - 72
Length of Day and Night - - - 72
Altitude - - - - - 73
Corrections - - - - - 74
What Next ? - - - - - 74
Contents - - - - - 75

ADVERTISEMENT.

A Copy of the Astronomical Geography will be sent post-paid to any address on receipt of 75 cents.

S. M. SARK,

Circleville, Ohio.

LIBRARY OF CONGRESS
0 003 629 975 7